



# **Future changes in the western North Pacific tropical cyclone activity: results from Project Athena**

Julia Manganelli<sup>1</sup>, Kevin Hodges<sup>2</sup>, Brandt Dirmeyer<sup>1</sup>, Jim Kinter<sup>1,3</sup>, Ben Cash<sup>1</sup>, Larry Marx<sup>1</sup>, Thomas Jung<sup>4</sup>, Deepthi Achuthavarier<sup>1,5</sup>, Jennifer M. Adams<sup>1</sup>, Eric L. Altshuler<sup>1</sup>, Bohua Huang<sup>1,3</sup>, Emilia K. Jin<sup>6,3</sup>, Peter Towers<sup>7</sup> and Nils Wedi<sup>7</sup>

<sup>1</sup> COLA, USA

<sup>2</sup> NERC Centre for Earth Observation, University of Reading, UK

<sup>3</sup> GMU, USA

<sup>4</sup> Alfred-Wegener-Institute for Polar and Marine Research, Germany

<sup>5</sup> USRA, USA

<sup>6</sup> KIAPS, South Korea

<sup>7</sup> ECMWF, UK



# Project Athena

- The World Modeling Summit (WMS) in May 2008 called for **a revolution in climate modeling** to more rapidly advance improvements in accuracy and reliability
- The WMS recommended **petascale supercomputers dedicated to climate modeling** based in at least 3 international facilities
  - Dedicated petascale machines are needed to provide enough computational capability and a controlled environment to support long runs and the management, analysis and stewardship of very large (petabyte) data sets
- The U.S. **National Science Foundation**, recognizing the importance of the problem, realized that a resource (*Athena*) was available to meet the challenge of the World Modeling Summit and **offered to dedicate the Athena supercomputer for 6 months** in 2009-2010
- An international collaboration was formed among groups in the U.S., Japan and the U.K. to use Athena to take up the challenge

Courtesy of Jim Kinter (COLA)

## ECMWF IFS Experiments (Project Athena)

Experiment	Model	Resolution	# of Cases	Years	Length
AMIP	T1279	16 km	1	1960-2007	47 years
	T159	125 km			
Time-slice (TS)	T1279	16 km	1	2070-2017	47 years
	T159	125 km			

- Integrated Forecast System (IFS) is an operational weather forecast model.
- 91 levels in the vertical.
- Uses hydrostatic approximation and parameterized convection.
- All runs are initialized on November 1.
- **SST and sea ice:**

**AMIP:** same 1.125° used for the ERA-40 reanalysis (monthly – before 1990; weekly – starting 1990; daily – starting 2002).

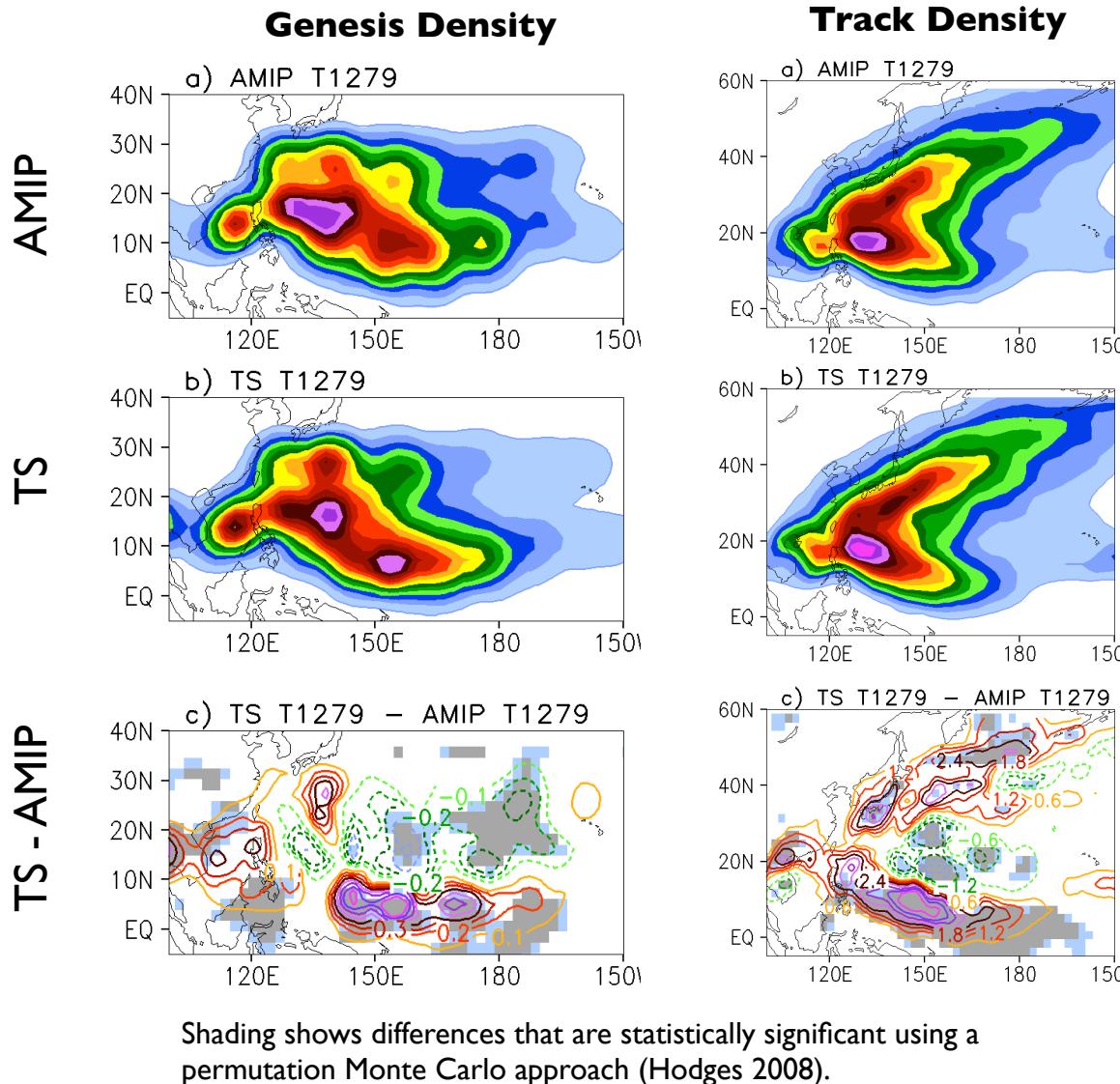
**TS:** differences in the annual cycle between 2065-2075 and 1965-1975 from the IPCC AR4 CCSM3.0 are added to the 1960-2007 observed record. **GHG concentrations** in IFS follow IPCC A1B.

## Projected changes: TC frequency, intensity and the PDI

	TS - AMIP (TI279)		
	Tropical Storm	CAT 1-2	CAT 3-5
Total TC frequency, counts per season	+2.2 (+7%)		
TC frequency per storm category	-2.4 (-12%)	+1.3 (+17%)	+ 3.3 (+70%)
Power Dissipation Index, *1.e11 m <sup>3</sup> /s <sup>2</sup>	+1.8 (+51%)		
Mean Peak Intensity, m/s	+3.4 (+12%)		
Mean Lifetime, days	+0.02 (+0.1%)		

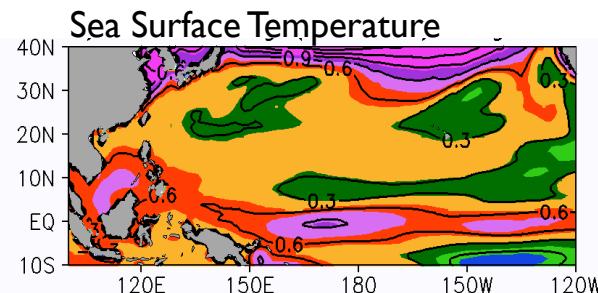
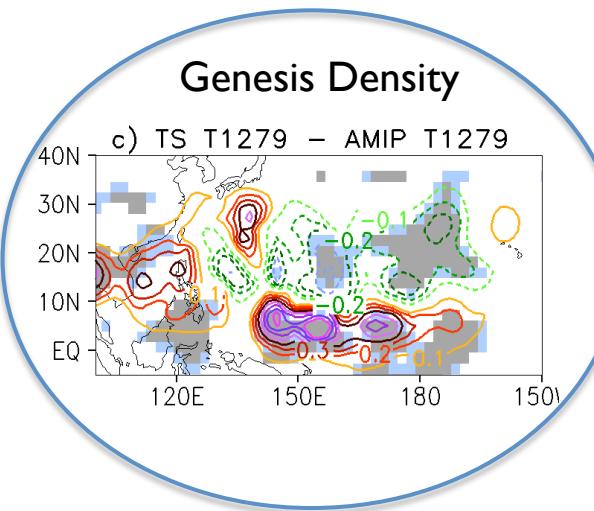
- for MJASON season, based on 47 years of data
- Values in **bold** are statistically significant at the 95% confidence level.

## Projected changes: TC frequency

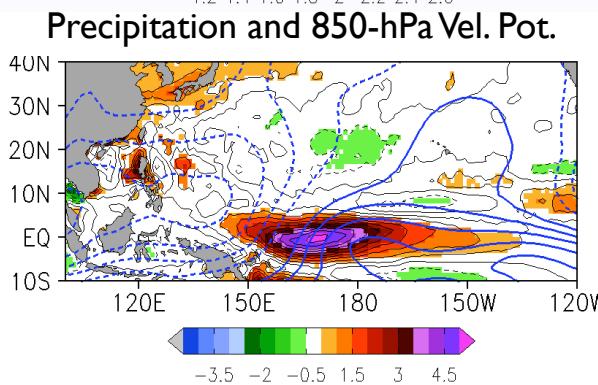


## Projected changes: TC frequency, cont.

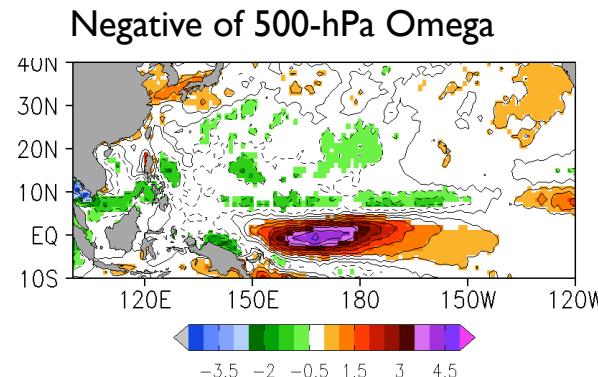
### TS – AMIP (T1279)



MJJASON means

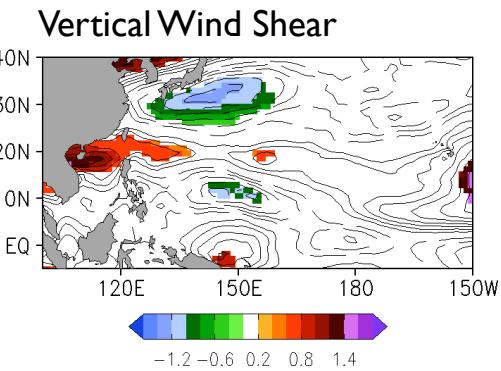
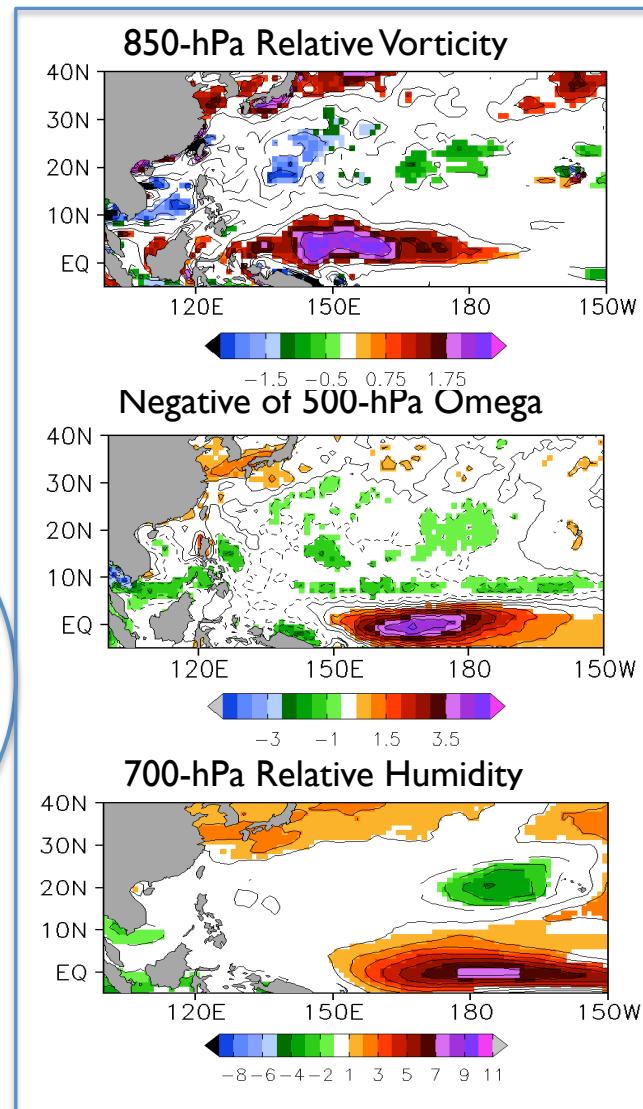
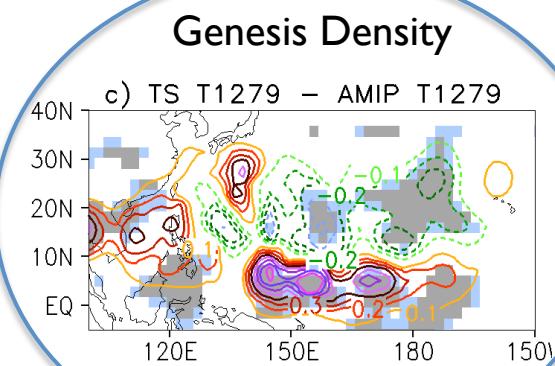
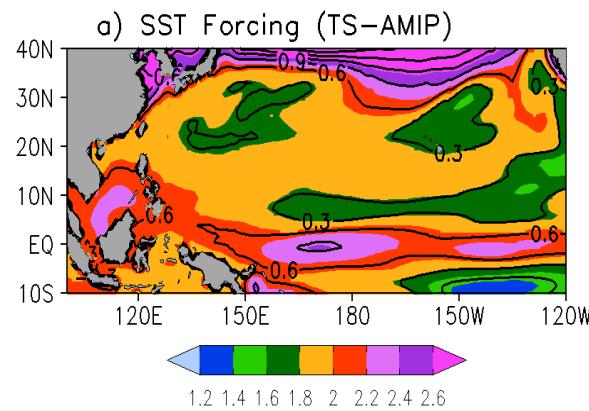


Shading denotes changes that are statistically significant at the 95% confidence level.

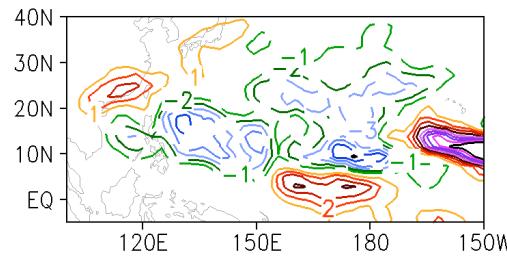


# Projected changes: TC frequency, cont.

## TS – AMIP (T1279)



Track Density of Tropical Disturbances

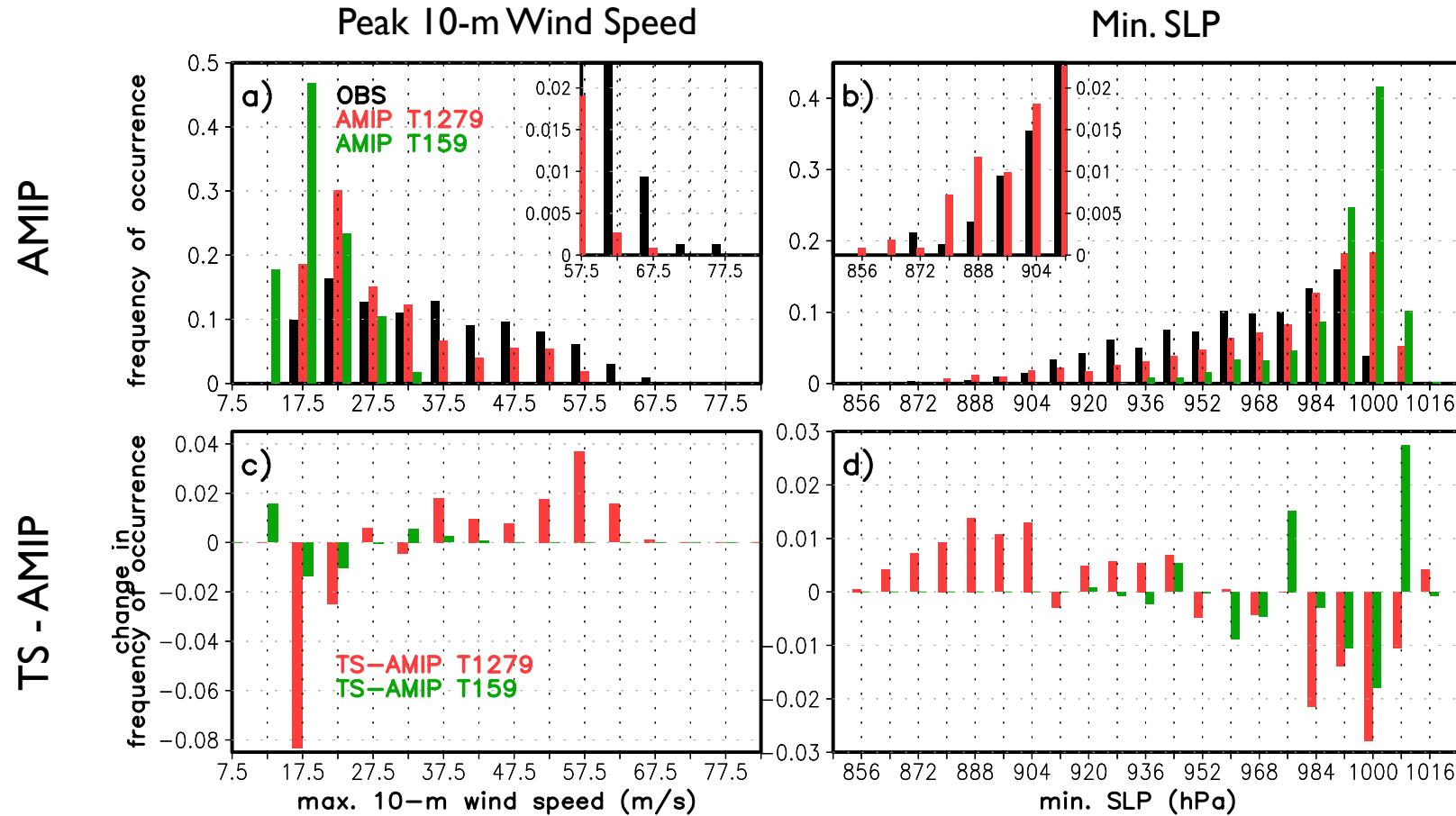


MJASON means

Shading denotes changes that are statistically significant at the 95% confidence level.

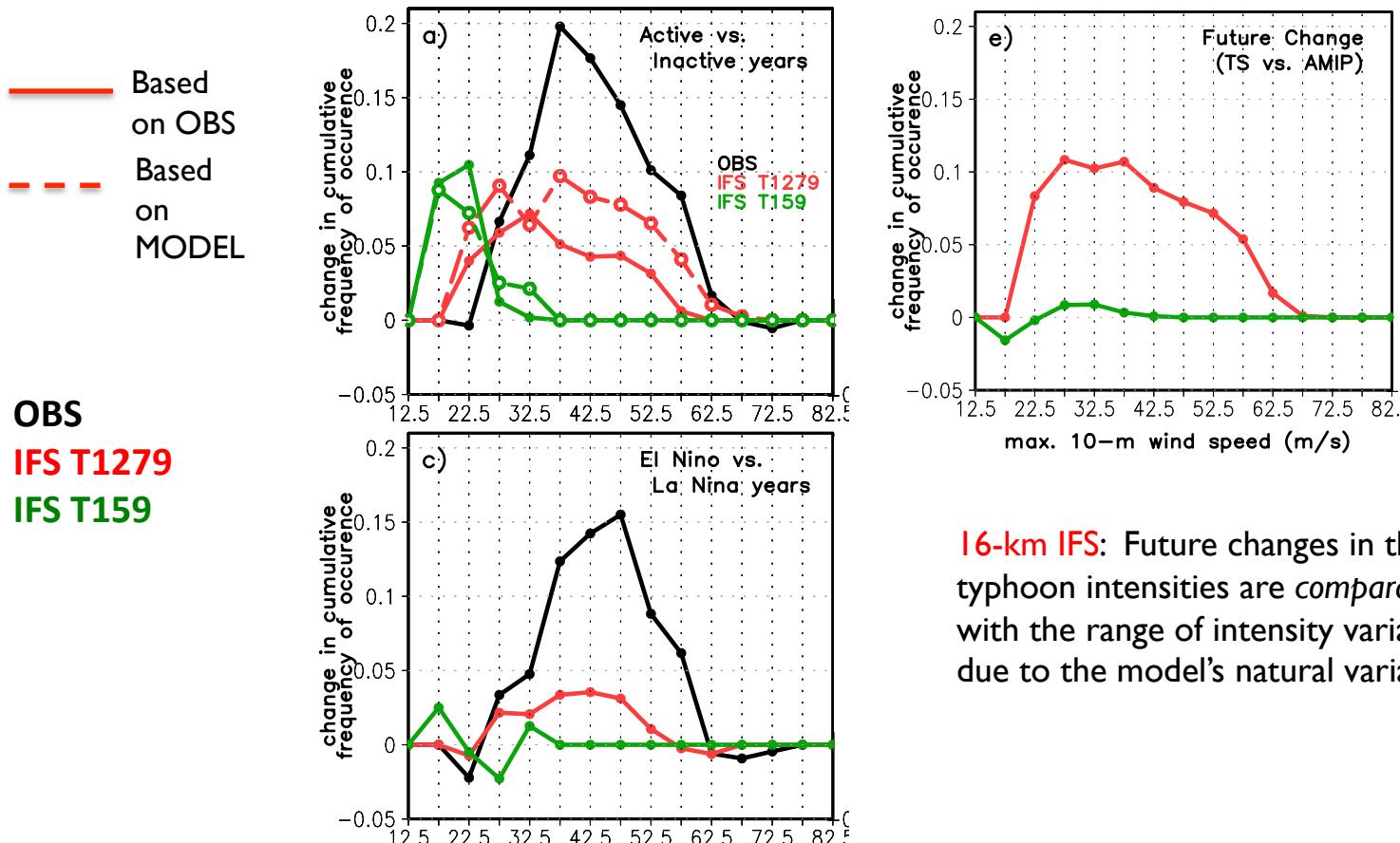
# Projected changes: TC intensity

## TC Intensity Distribution



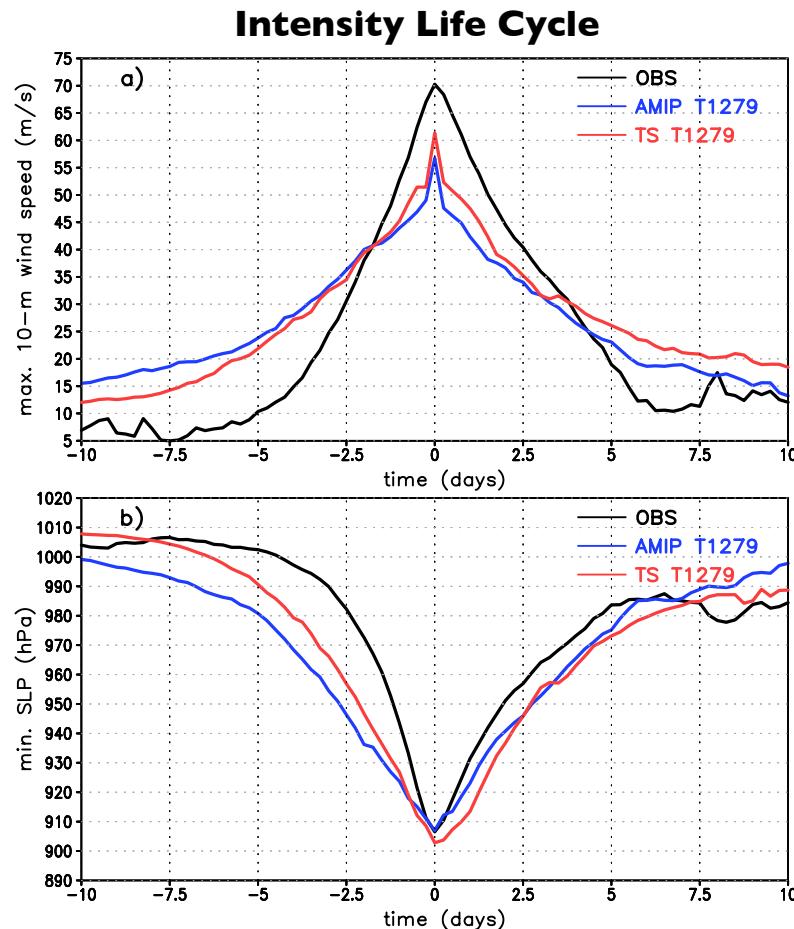
## Projected changes: TC intensity, cont.

### Changes in the Cumulative Distribution of TC Intensity



16-km IFS: Future changes in the typhoon intensities are *comparable* with the range of intensity variations due to the model's natural variability.

## Projected changes: TC intensity, cont.

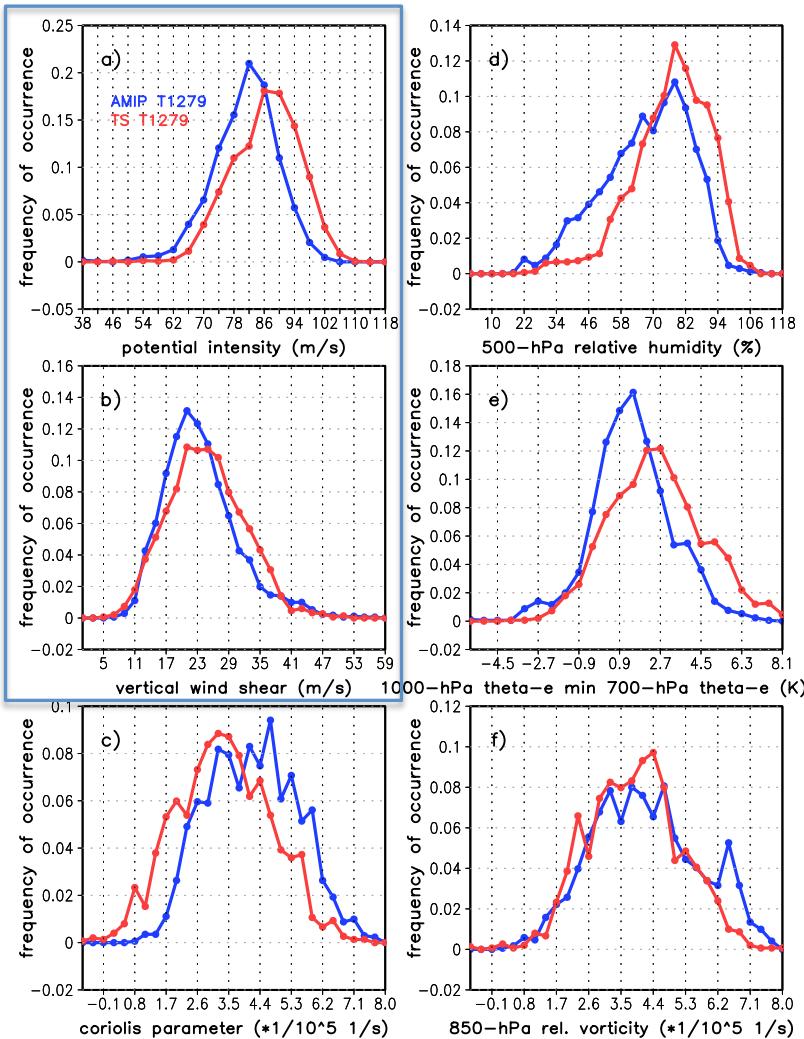


### Super-typhoon Composites

	OBS	AMIP T1279	TS T1279
# of storms	48	47	47
Maximum 10-m wind speed, m/s	$\geq 65.0$ or CAT 5	$\geq 54.0$ or CAT 4	$\geq 58.5$ or CAT 4
Intensification time, days	5.6	13.8	11.7

# Projected changes: TC intensity, cont.

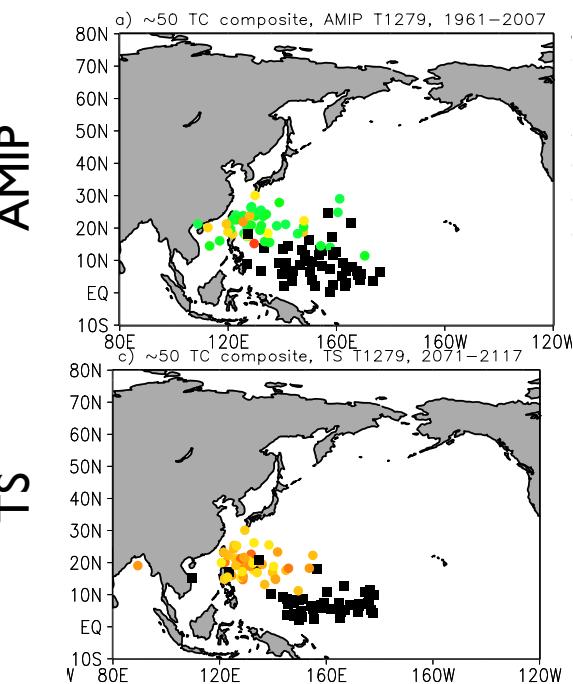
## Frequency distributions of storm-ambient conditions (for super-typhoon composites during their intensification phase)



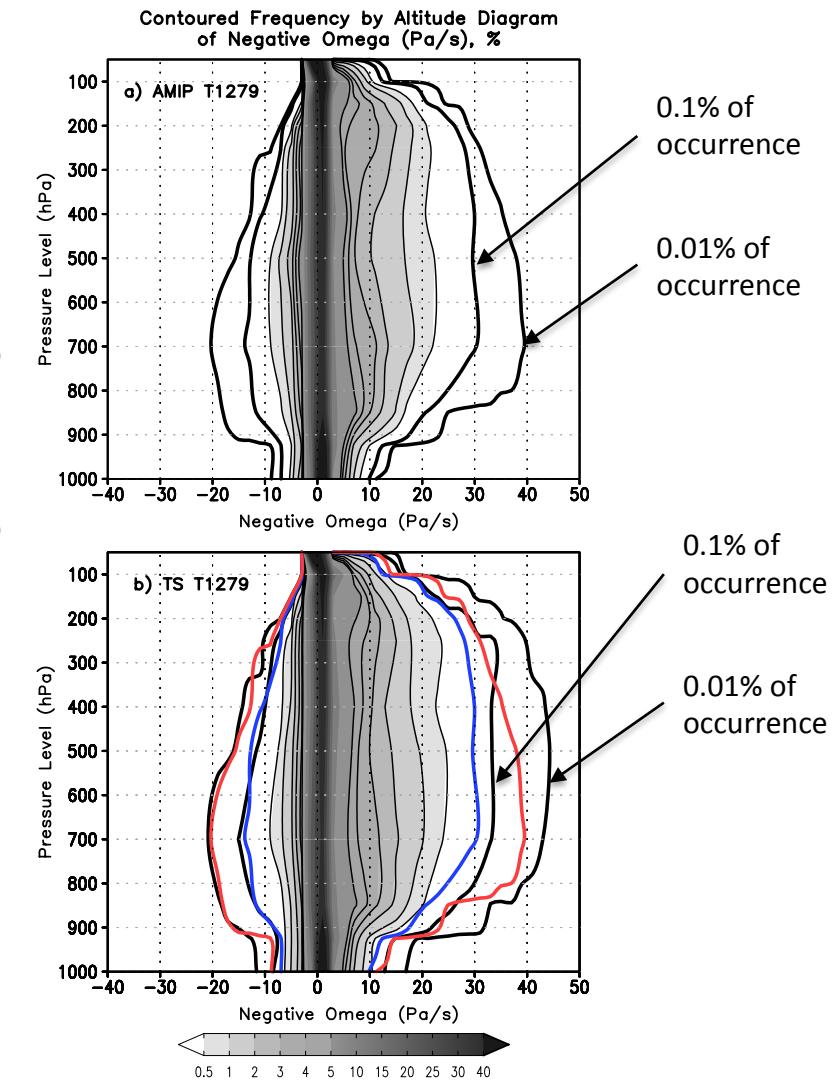
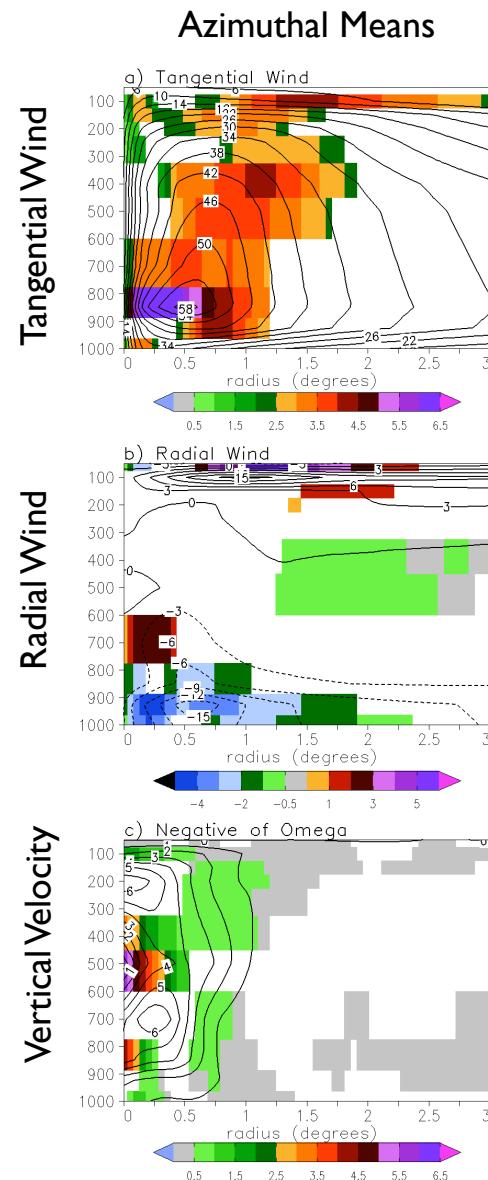
Upward shift in the frequency of the most intense TCs could be due to:

1. an increase in their lifetime,
2. higher intensification rate,
3. an increase in potential intensity (PI) or decrease in VWS, for instance.

*These factors are not necessarily mutually exclusive!*



# Projected changes: TC structure



## Projected changes: TC structure, cont.

